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THE APPLICATION OF ANALYTIC HIERARCHY PROCESS IN SELECTING PERSONNEL – A CASE STUDY

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One of the most important and difficult decisions a manager makes is to select personnel. The criticality of this decision results in most managers struggling to find an appropriate selection approach. The interview approach is the most common method to selecting personnel. Many users seek to quantify this method by arbitrarily assigning weights and ranking scales for candidate answers. This paper seeks to show the use of AHP to provide a structured and multidimensional approach in assigning weights and ranking candidates. A case study is used to demonstrate the development and application of the structured AHP approach in selecting personnel.

Introduction

One of the most important and difficult decisions a manager will make is to select personnel. Most managers will agree that employees are the most vital resources to the success of an organization. The criticality and infrequency of this decision will result in most managers struggling to find the appropriate selection approach. The anxiety in making this critical decision is justified by the high degree of subjectivity associated with the selection process, its impact on the organization and the corresponding cost from making a wrong decision. Terpstra and Rozell (1993) noted an improvement in organization performance with an increased use of selection methods.

The methods used to effectively select personnel are diverse and vary by the organization. Wilk & Cappelli (2003) note the actual selection process used by an organization is based on work related factors such as skill requirements, training and pay. When job descriptions require higher skills and training the organizations utilize selection methods, which facilitate more control such as interviews and testing. The 3000 employers who took part in the study by Wilk & Cappelli (2003) identified the interview process as the most common technique for personnel selection. The interview process can be supplemented by including other evaluation methods, including psychological testing, aptitude tests, motor skills test and personality traits. Generally, management perceives the process of interviewing candidates to be a reliable and valid method for evaluating a candidate's skills. Though the interview process is used extensively, research has described various developmental and interviewer bias factors which can detract from the validity of the traditional interview approach (Hennerman et al, 1989).

Interviewers may make snap judgments about interviewees based on their initial impressions of the candidates. Springbett (1958) noted that interviewers make decisions during the first few minutes of an interview. These initial impressions may have little relationship to job related performance. The use of a single evaluator conducting the interview can increase the degree of subjectivity in the decision process. This increased subjectivity is the result of the evaluator's conscious or subconscious bias based on their experiences, which form their image of the ideal candidate (London and Hakel, 1974). The lack of job related questions with appropriate weighing could result in positive or negative responses being given too heavy a weight in the selection decision. The lack of a standardized means for recording evaluations can impact how a candidate's responses are remembered or perceived after the interview. The lack of a structured selection process can have legal and cost implications. First, compliance with the Civil Rights Act of 1964, the Equal Employment Act of 1972 and the Vocational Rehabilitation Act of 1973 mandates a selection process to be built on a foundation of documented requirements to prevent discrimination.

For a selection process to simply not discriminate is not adequate, but must be structured within the process. Buckley et al (2000) state an oral interview of any kind is, by definition, a test and must meet the same fairness requirements as other types of tests. The cost of noncompliance, whether intentional or not, can be in the form of legal expenses, alienation of a group of customers, or a protracted selection process. Secondly, a selection process must allow the best candidate to be chosen. The process must focus on how well the candidate matches a set of predefined job skills rather than good verbal and presentation skills. The potential cost of misjudging a candidate's ability to perform as anticipated is at a minimum the expense in time, training and money of going through another selection process.

This paper seeks to demonstrate the development and use of a structured personnel selection methodology using the Analytical Hierarchical Process (AHP). This pair-wise comparison approach using multiple evaluators is described in a case study. The remaining sections of this paper describe a means to overcome the interview shortcomings, the use of quantitative methods, the use of AHP in previous studies, a description of AHP methodology, a description of the Case Study, the corresponding results and a discussion of the findings.

How to Overcome Interview Shortcomings

For an organization to effectively use the interview process requires the user to minimize the previously mentioned interview shortcomings. Several studies have promoted the use of a structured interview process which uses predefined open ended questions which are based on task oriented questions (Lindaman, 1997; Levine et al, 1997). Green (1991) proposed a methodology, which describes an approach to structuring the interview process. First, perform a Job Analysis. A job analysis describes the content and complexity of a job in such a way that the required knowledge, skills and abilities and other characteristics needed by the applicants can be identified to successfully function within the new position (Schmitt & Chan, 1998). Second, develop selection criteria, which is based upon the characteristics, defined in the Job Analysis. The selection criteria should be reflective of the job requirements, skills, defined in writing and avoids the issues with psychological processing. Third, develop interview questions, which are based upon occupational qualifications, adhere to legal guidelines, non-cueing, and evaluates past performance over philosophy. Fourth, an interview should provide for a standard treatment of all candidates for the position. This includes asking the same or equivalent job-related questions and avoids questions or comments that relate to "protected" groups. Fifth, each interviewer should take notes on each candidate. These notes should be descriptive, nonjudgmental, and taken during the interview. These notes will enhance the evaluators' recall of specific aspects of the candidate, especially when the interview process is conducted over a long span of time. Finally, a fair and consistent method of selection must be available to measure the evaluator's observations. This selection method must not only consider the interview observations but also consider any legal criteria afforded to "protected groups."

Selection Process: Quantitative or Qualitative?

How should the selection committee determine the best candidate based on the established job related characteristics and the candidate's responses to the structured interview questions? There is some discussion as to whether to use a qualitative or quantitative approach to rank each individual's qualifications. One thought is that the selection process should be entirely based upon consensus building. Barney (1989) defines this approach as a group, which is provided an opportunity to present their views and all members accept the group decision. In the event the selection committee does not agree upon a best choice, the pros and cons of each candidate are discussed and additional polling is taken until the group reaches consensus. Several problems can exist with this approach: Even though a committee format is utilized, defending a challenge of the decision can be difficult. Each "protected group" could base a challenge on insufficient representation on the committee. Second, decisions by a group can suffer from the influence of group dynamics. A group's decision can be influenced, consciously or unconsciously, by the position taken by a more senior committee member or the most articulate member. Third, this method promotes group buy-in at the expense of the time required to arrive at a given result.

Taylor et al (1998) identify the personnel evaluation process as a problem in identification, weighting and evaluation. We could consider the steps in a job analysis and the corresponding candidate responses as satisfying the "identification" component of the process. Taylor and Ketcham (1998) go on to identify the principle difficulties of personnel evaluation as: 1) determining a set of attribute weights and 2) assigning attribute scores to each candidate. The assignments of weights to the job related attributes in advance of the interview could address several pitfalls of the interview process. First, an individual interviewer's weighting of any specific attribute will remain the same for each candidate's response. The interviewer is limited in the amount of weight, which can be given to any specific response. So the impact on the final score of an especially positive or negative response by a candidate will be kept within a predetermined perspective relative to all the identified attributes. Second, the criteria allows the interviewer to focus on the important job-related qualifications of each candidate rather than relying too much on a "gut feel" approach. Third, if the committee is asked to support the decision, any defense can be based on a documented list of job attributes rather than a subjective opinion.

A defense based on a subjective opinion can be inferred as a rationalization of the decision. The quantitative weighting approach does have the weakness of how to establish the weight for each attribute. The assignment of the weights can be considered arbitrary if a structured approach is not defined. The "evaluation" component consists of establishing a scale to measure each candidate's responses, a means to calculate the results and how to decide if one candidate is definitively superior. The best candidate may not simply be the one having the higher numerical score. An example is factors, which represent discrete attributes such as having a unique skill, or group membership, which was not initially considered in the job analysis and should be considered. It could be suggested that it requires a quantitative approach to formalize the selection process and narrow the field then use a qualitative aspect to allow for consideration of intangible criteria and to serve as a "sanity check."

Analytic Hierarchy Process

The focus of this paper is to define a feasible quantitative methodology to be used in a personnel selection process. The personnel selection process can be classified as a Multiple Criteria Decision Making (MCDM) problem. A simple MCDM method is to identify a group of criteria, which support the problem objective then subjectively assign a weight to each criterion. Each criterion is given a value based on a linear numeric scale, which represents the rating, by an evaluator. A final score is obtained by combining the assigned weights to the assigned criterion value then averaged. Less subjective linear methods include Goal Programming, Compromise Programming, and the Analytic Hierarchy Process (AHP). Because the first approach is simple to incorporate and understand it is most likely to be readily accepted. The simple MCMD approach is one dimensional in the weighting of the decision criteria. This is a basis for its subjective nature. Saaty's (1980) Analytic Hierarchy Process (AHP) considers not only where the decision maker rates a specific criterion on a numeric scale but also how it relates to all other decision criteria. Saaty argues that the direct assignment of weighted values to the criteria is too abstract for the evaluator, especially in complex problems, and will result in inaccuracies. Judgments based on pair-wise comparisons give the evaluator a basis on which to reveal his or her intended preference. Olson et al (1995) cites feedback capable of providing the decision maker with accurate and consistent information, reflecting the decision maker's preference, is a necessary feature of decision aids when applied to selection problem.

AHP has been used in a number of diverse applications where qualitative decisions are made from multiple criteria. Forman and Gass (2001) cite a wide variety of areas in which AHP has been used including alternative selection, prioritization/evaluation, resource allocation, benchmarking, quality management, public policy, healthcare and strategic planning. Several information technology studies have explored the use of AHP for ranking investments, outsourcing decisions, selecting operating systems and selecting simulation software (Borenstein & Betencourt, 2005; Kearns, 2004; Pandey & Bansal, 2004; Roper-Lowe & Sharpe, 1990; Davis & Williams, 1994). Kahraman et al (2003) and Zaim et al (2003) used a fuzzy version of AHP to select suppliers in the retail and television production industries. Sun (2001) applied AHP to the complex and sensitive decision of military base closures in Taiwan. Millet and Wedley (2002) proposed methods for modeling risk and uncertainty with AHP. They used four case studies to derive probabilities, multiple criteria outcome measures, risk criteria and risk adjustment factors. Partovi et al (2002) describe a general decision making framework based on AHP for making and documenting quality–related decisions as applied to the implementation of ISO 9000-1994. Searcy (2004) demonstrated how to use AHP to determine the metrics and corresponding weights of a balanced scorecard.

AHP and Personnel Selection

There have been several studies performed using AHP for personnel selection in an academic application. Lootsma (1980) recalls using AHP while as a member of a committee to select a senior professor for an operations research department. Taylor et al (1998) used AHP to down select a group of candidates to be interviewed for a dean's position. Each selection application was addressed by a committee using AHP that approximated a method described by Johnson (1980). This methodology breaks down the AHP application into 4 steps:

Step 1: Setting up the decision hierarchy by breaking down the decision problem into a hierarchy of interrelated decision elements
Step 2: Collecting input data by pair-wise comparisons of job attributes.
Step 3: Use the "eigenvalue" method to estimate the relative weights of decision criteria.
Step 4: Aggregate the weighted decision criteria to arrive at a set of ratings for the alternatives.

The previous studies allowed each committee to develop a priority matrix (Step 2) by consensus for the weights of the various selection criteria. This allows a straightforward application of AHP with the advantage of having a single set of "eigenvalues" to calculate the candidate ranking order. But this method can produce results with the same group dynamics bias, which was described earlier. In addition, when a group consensus approach is used to assign relative values between a pair of attributes the weighting results can exhibits a tendency towards the midpoint of the scale. The resulting narrow range of weights can result in attribute ratings with approximately the same values. This lack of diversity in numerical values can diminish the process' ability to discriminate between good and bad candidates. Lootsma (1980) used consensus among committee members in the assignment of candidate response values (Step 4). While Taylor et al (2002) allowed each committee member to assign their own candidate scores for each criterion but then arithmetically averaged the weighted candidate scores to arrive at a final ranking.

Saaty (1986) identifies four axioms which must be satisfied for the application of AHP to be valid: (1) reciprocal condition: when comparing two objects, the intensity of preference of the opposite comparison is the reciprocal of the original comparison; (2) homogeneity: elements being compared should not differ on a given level: (3) dependence: weights of the higher level do not depend on the lower level elements; (4) expectations: all relevant criteria and alternatives are represented in the hierarchy.

The criticisms of the AHP technique include ambiguity in pair-wise comparison (Dyer 1990), criteria weight (Belton and Gear, 1985), ratio scales (Dyer, 1990) and identified problem rank reversal (Schoner et al, 1993).

CASE STUDY

The application of AHP in personnel selection is demonstrated in the following case study. An aerospace company seeks to select a technical representative to work with a foreign supplier and reside within that country. The company's current personnel selection process requires a committee to perform a job analysis and identify the job attributes. A committee of 3 members representing expertise in the technical, contracts and management areas of the job, where selected for this task. The committee determines from the job analysis that a successful candidate should possess positive attributes in the following twelve (12) areas:

- Customer Orientation
- Adaptability
- Verbal Skills
- Quality Commitment
- Tooling Knowledge
- Initiative
- Composite Material Knowledge
- Part Assembly Knowledge
- Statistical Process Control
- Problem Solving Skills
- General Knowledge of Specific Part
- Process Improvement Experience

The committee believes that the chosen candidate should be especially strong in several key areas. One of those areas is technical competency with the design, fabrication and assembly of the subject part. In addition, the chosen candidate must be a self-starter with good problem solving skills, as they would be working without onsite supervision. Also, a very important attribute is the selected candidate's ability to communicate with all levels of management both within our company and the foreign supplier and do so without creating an international incident. Finally, the candidate must be willing to spend two (2) years at this position.

Collecting Input Data by Pair-Wise Comparisons

Once the job attributes have been identified the committee will take up the task of assigning weights to the attributes. The company's traditional approach had been for each committee member to assign individual a priori weights. This approach has lead to each committee member identifying a different preferred candidate. In an effort to arrive at a common final candidate, this committee chose to use the pair-wise comparison approach in AHP. Prior to starting the interview process, this committee requires each evaluator to create an individual priority matrix for establishing job attribute weights. A 9-point Likert scale (Saaty,1980) is used to define the relative importance between each attribute within the priority matrix:

VALUE	INTERPRETATION
1	Attribute A and C are of equal importance
3	Attribute A is slightly more important than attribute C
5	Attribute A is strongly more important than attribute C
7	Attribute A is very strongly more important than attribute C
9	Attribute A is absolutely more important than attribute C

Values 2, 4, 6, or 8 could be used if the interviewer believes the response falls between the scale interpretations given above. The priority matrix for each selection attribute looks similar to the following matrix:

Figure 1: Typical priority matrix

Attribute	A	B	C	D	E
A	1	2	3	4	1/3
B	1/2	1	1/4	1/3	2
C	1/3	4	1	1/7	1/9
D	1/4	3	7	1	1/6
E	3	1/2	9	6	1

The reciprocal axiom for AHP allows identification of the level of importance between each pair of attributes only once. The inverse relationship between the pair of attributes is considered to be the reciprocal of the previously assigned value. For example, the relationship between Attributes A to C is identified but not between Attributes C to A. Based on the values in figure 1, the Attributes A to C relationship is rated a 3 which indicates that Attribute A is "slightly more important" than attribute C. The Attributes C to A relationship is treated to be the inverse of the initial relationship and is automatically assigned a value of 1/3. This reciprocal property is useful in eliminating half of the attribute relationship assignments for each priority matrix. The number of relationships for a priority matrix, which need to be assigned by the evaluator, is equal to n(n-1)/2, with "n" equal to the number of attributes. This selection effort has twelve job attributes, which required identification of 66 one-way relationships. Without the reciprocal axiom, a large number of relationships would make it difficult to keep track of each corresponding initial and inverse relationships. This would lead to inconsistencies in relationships, which diminishes the usefulness of AHP.

Scoring Candidate Responses

The committee is to prepare a single question for each of the twelve job attributes, which will be posed to each of the candidates. The questions are designed to provide the evaluator an understanding of each candidate's skill level and past performance for a given job attribute. Along with each job attribute question a series of reference factors are developed. These reference factors are used as a standard upon which the interviewer can assess the candidate's responses. Each reference factor has a ratings scale upon which the evaluator documents how well the candidate's response addresses a specific reference question. The scale is a 5-point Likert with the rankings: CL (Clearly Lacking in Response), L (Lack), P (Some Presence), SP (Strong Presence) and VSP (Very Strong Presence in Response). Each evaluator rates the candidate's response to the job attribute question by reviewing the rankings given to the reference factors and any notes taken which relevant to the specific question. The evaluator assigns one of the 5 ranks as the candidate's overall rating for the specific job attribute. Assigning a rating between the identified rankings is acceptable if the interviewer feels compelled.

Once all the candidates are interviewed the responses from each candidate is measured relative to the other candidates' responses for each job attribute. This relative measurement is performed using the same priority matrix approach described for the weighting of job attributes. Each evaluator creates a series of candidate response matrices for job attributes. The candidate response matrix for the Initiative attribute is given as an example (figure 2).

Figure 2: Initiative Candidate Response Matrix

Candidates	A	B	C	D	E	F	G
A	1	4	½	1	2	1	4
B	¼	1	1/5	¼	1/3	¼	1
C	2	5	1	2	3	2	5
D	1	4	½	1	2	1	4
E	½	3	1/3	½	1	1/3	3
F	1	4	½	1	3	1	4
G	¼	1	1/5	¼	1/3	¼	1

To perform the pair-wise comparison of candidate response ratings required the committee to create a scale to establish a relational value between the candidate's ratings for each attribute question. This relational value of candidate's ratings is used as the input to the candidate response matrix for each job attribute. The relational value of candidate rating is computed by comparing the job attribute ratings for a pair of candidates. One of the candidates is picked as the reference, such as those candidates noted on the vertical axis of the priority matrix. If the reference candidate has a higher ranking than the other candidate an integer value based on the distance between the candidates scores is assigned as the relational value in the priority matrix. If the reference candidate has a lower ranking then the reciprocal of the ranking distance is assigned. The priority matrices utilize the 9-point Likert scale; those candidates who are rated the same are assigned a relational value of 1. If a candidate comparison differs by a single rating (VSP vs SP) on the response scale the relational value for the priority matrix is a 3. If each candidate ratings being compared are at the opposing ends of the response scale (VSP v CL) the relational value is a 9. For example, if candidate A, the reference, is rated VSP and candidate B, the comparison, is rated SP on initiative, then candidate A would be assigned a

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value of 3 relative to candidate B. Conversely, candidate B, the reference, is rated 1/3 relative to candidate A, the comparison, as set forth in the reciprocal axiom. If one of the evaluators feels candidate B response falls between the above rankings then a score such as VSP/SP is given. Then candidate A (VSP) would be rated a 2 relative to candidate B (VSP/SP).

Calculating Attribute Weights and Candidate Response Scores

Once the relative data has been inputted into the priority matrices it is necessary to derive a means to calculate the specific job attribute weights and the normalized candidate response scores. Though, there is commercial software (Expert Choice) for use in computing these values the committee chose to develop a template for entering the priority matrix data and use a spreadsheet to compute these values. The spreadsheet used equation (1) to define the candidate aggregate score as the sum of the weighted attribute scores. This aggregate score is used latter in the process to rank the candidates.

$$\text{Candidate (k) score} = \sum_{i=1}^{N} W_i * A_i \quad (1)$$

Where, W_i is the weight for the attribute i, A_i is the normalized candidate response score for attribute i and N is the total number of attributes. The spreadsheet computation of attribute weights and normalized candidate response scores used a method described by Winston (1991) and Searcy (2004). This method is performed in two steps: First, normalize each cell in the priority matrix by dividing each of the cell entries in the matrix by the sum of the column (j) it occupies ($r_{ij} = C_{ij} / \sum_{i=1}^{n} C_{ij}$). Second, sum each normalized row (i) in the matrix and divide by the number of entries (N) in each row ($W_i = \sum_{j=1}^{n} r_{ij} / N$). Depending on the data in the priority matrix result is either a job attribute weight (W_i) or a normalized candidate response score (A_i).

Consistency of Priority Matrix Assignments

One of the issues with assigning values in a pair-wise comparison approach is that of consistency. Inconsistency can result from the evaluator assigning a large number of relationships between multiple pairs of attributes being compared. An example of this issue is if Attribute A is rated a 3 compared to Attribute B and Attribute B is rated a 2 compared to Attribute C, to be consistent Attribute A should be rated a 6 compared to Attribute C, otherwise an inconsistency exists. If the relationships are inconsistent then the accuracy of the calculated weights may be questionable. To determine the acceptability of the weights AHP needs a means to check for the level of inconsistency. Saaty (1980) and Wintson (1991) hold that when the evaluator assigning values to the priority matrix is perfectly consistent then equation 2 is valid.

$$\mathbf{A}\, W^T = \mathbf{n}\, W^T \quad (2)$$

A is the attribute priority matrix, $\mathbf{W}^t$ is the vector of attribute weights, and **n** is the number of attributes. But because perfect consistency is seldom found in reality, AHP proposes that an approximation of equation 2 can be found by replacing **n** with Δ_{max}, the largest number to provide a non-trivial solution. This approximation relationship is shown in equation (3).

$$\mathbf{A}\, W^T = \Delta_{\mathbf{max}}\, W_{max} \, (3)$$

If the inconsistency does not vary significantly then Δ_{max} will approximate **n** and the actual relative weight $\mathbf{W}_{max}$ and $\mathbf{W}^T$ will be approximately the same. Expert Choice calculates exact values of the decision maker's consistency. To provide a reference for acceptable inconsistency AHP utilizes a Consistency Index (CI).

$$CI = \frac{(\Delta_{max} - n)}{(n-1)} \quad (4)$$

This committee used a 4-step approach identified in Winson (1991) to check for inconsistency. The computation of the Consistency Index (CI) for the Assembly Knowledge attribute matrix is given as an example:

Step 1: Compute $\mathbf{AW}^T$ for each attribute and candidate response priority matrix. Depending on the priority matrix being reviewed for consistency the values in $\mathbf{W}^T$ are the weighted results from either a job attribute weight (W_i) or a normalized candidate response score (A_i) pair-wise comparison.

Figure 3: Assembly Knowledge Matrix for Consistency Index

Candidate	A	B	C	D	E	F	G		W^T		AW^T
A	1	1/3	1	3	1/3	3	1		0.114		0.806
B	3	1	3	5	1	5	2		0.272		1.942
C	1	1/3	1	3	1/3	3	1		0.114		0.806
D	1/3	1/5	1/3	1	1/5	1	1/3		0.045	=	0.319
E	3	1	3	5	1	5	3		0.289		2.067
F	1/3	1/5	1/3	1	1/5	1	1/3		0.045		0.319
G	1	½	1	3	1/3	3	1		0.121		0.856

Step 2: Compute Δ_{max}: $\Delta_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{\text{ith entry in } AW^T}{\text{ith entry in } W^T}$ (5)

Inputting the results from step 1 into equation 5 gives the Δ_{max} as:

$$\Delta_{max} = \frac{1}{7}\left[\frac{0.806}{0.114}+\frac{1.942}{0.272}+\frac{0.806}{0.114}+\frac{0.319}{0.045}+\frac{2.067}{0.289}+\frac{0.319}{0.045}+\frac{0.856}{0.121}\right]$$
$$= 7.085$$

Step 3: Compute the consistency index (CI) as follows:

$$CI = \frac{(\Delta_{max} - n)}{n-1} \quad (6)$$

Using the previous results from Step 2 the CI is computed as:

$$CI = \frac{7.085-7}{7-1} = 0.0141$$

Step 4: Compare CI to the random index (RI) for the appropriate value of n. Consistency is typically found acceptable when the ratio of CI / RI < 0.10. The random index for 7 candidates is 1.32 (Winston, 1991). The CI / RI ratio for Assembly Knowledge is 0.011 (0.0141 / 1.32). Since this CI / RI ratio is less than 0.10 one can infer that the evaluator was consistent in the assignment of ratings for the Assembly Knowledge attribute. A Consistency Index is developed for each evaluator's ratings for each job attribute matrix and candidate response score matrix. The assessment of the 39 Consistency Indices (1 attribute matrices plus 12 candidate attribute comparisons times 3 evaluators) was greatly facilitated by the use of the spreadsheet template.

Making the Selection

The personnel selection methodology at this aerospace company does not provide guidelines on how to aggregate the evaluator's scores and make the final selection. This committee chose to use two approaches in making a final ranking of candidates. The first ranking approach requires each evaluator to rank the candidates based on the AHP derived aggregate attribute scores (equation 1). Each evaluator will select the top 3 candidates from their rankings for comparison with the other evaluators' top 3 candidates.

The second ranking approach creates a single ranking of candidates by computing the geometric average of all evaluators' AHP derived aggregate attribute scores for each candidate. The use of geometric averaging to combine multiple evaluators' rankings is well documented in the literature on AHP (Aczel & Saaty, 1983; Searcy, 2004; Sunn, 2001). The evaluators will review the top 3 candidates from this single ranking.

In both approaches, if agreement is found on the top ranked candidate then a brief review of the candidate and job attributes is held. The top ranked candidate is selected unless new information is obtained or a procedural issue is identified. In the event that there is disagreement by one or more of the evaluators on the ranking of a candidate, the evaluators will discuss their objections and support their ranking preference with the candidate response data. The discussion will continue until agreement on the top candidate is achieved.

This committee chose to use this combined quantitative (AHP) and qualitative (ranking consensus) to address possible imperfections in a purely quantitative model. The committee members recognize that measuring impressions and observations about a candidate is subjective. The committee believes that even a trained evaluator will have difficulty in accurately converting these subjective impressions to quantitative values. Yet, the committee uses the quantitative approach to provide structure for the selection problem. This committee chose to draw upon the strengths of each of these techniques by including both in the solution.

RESULTS

The committee was provided with seven candidates by the Human Resources department. These candidates were identified through recommendations of their supervisors or submittal of applications via the company's intranet job posting. The committee met prior to the interviews and reviewed the job analysis. A pair-wise comparison was conducted on the job attributes by each evaluator. The interview committee reviewed the job attribute weights results (table 1). The committee found the diversity in the attribute weights assigned by each interviewer to be of interest. Even though a review thorough review was conducted of the attributes described in the job analysis, the expectations for the "ideal" candidate still differed between the members of the interviewing committee. Evaluator 1 stressed the technical selection criteria as being most important. This evaluator focused on the position's requirement for a person who could readily answer the suppliers' questions without much assistance from the home organization. The difference in time zones makes communication with the home office difficult and can lead to potentially long delays. Interviewer 2 stressed the person's communication and people skills. This evaluator felt it necessary that the selected individual be able to adapt to the cultural differences in order to effectively communicate both technical and non-technical messages. Evaluator 2 felt that without the ability to adapt culturally, both professional and personally, the person would be ineffective in this position. Interviewer 3 presented a more balanced weighting between the technical skills and the

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communication skills. This evaluator stressed that both skills are important and being expert in either is not as important as being competent in both skills. This diversity in attribute weights demonstrates that individually the evaluator will use their experience and position bias in rating a candidate. The need for the use of committees in personal selection is supported by these results.

Table 1: Job Attribute Weights

ATTRIBUTE	Evaluator 1	Evaluator 2	Evaluator 3
Customer Orientation	0.0754	0.1968	0.1293
Initiative	0.1636	0.1672	0.1327
Verbal Skills	0.0853	0.1556	0.0727
Quality Commitment	0.0495	0.0965	0.0789
Problem Solving	0.0530	0.0776	0.0417
Assembly Knowledge	0.0853	0.0503	0.1224
Composite Knowledge	0.1636	0.0480	0.1224
Adaptability	0.0343	0.0905	0.0213
SPC	0.0231	0.0378	0.0386
Tooling Knowledge	0.0782	0.0315	0.0590
Part Mfg Knowledge	0.1636	0.0264	0.1255
Process Improvement	0.0252	0.0218	0.0537

The committee members rotated posing the questions noted on the interview sheets to each candidate. Each evaluator rated how well each candidate's responded to the attribute question and entered those ratings into the spreadsheet template, which created a score relative to the other candidates. Table 2 exhibits this difference in relative scores by showing each evaluator's scores for candidate C. Though each evaluator heard the same response to the Attribute question there was considerable range in the relative scores. Evaluator 1 rated candidate C's response on the customer orientation question quite high (0.2935) relative to other candidate, while evaluators 2 & 3 gave much lower ratings (0.1983 & 0.1397, respectively). The range of Composite Knowledge ratings is even more dramatic as evaluator 2's relative score for candidate C was 0.2026, while evaluators 1 & 3 rated this candidate near the bottom of the candidate pool (0.0756 and 0.0647, respectively).

Table 2: Normalized Candidate Response Score for Candidate C

Candidate C	Evaluator 1	Evaluator 2	Evaluator 3
Customer Orientation	0.2935	0.1983	0.1397
Initiative	0.1027	0.1800	0.0483
Verbal Skills	0.2783	0.2175	0.1187
Quality Commitment	.01640	0.1787	0.1068
Problem Solving	0.0998	0.1983	0.1437
Assembly Knowledge	0.2037	0.1579	0.1132
Composite Knowledge	0.0756	0.2026	0.0647
Adaptability	0.1486	0.2057	0.1788
SCP	0.1594	0.2909	0.1451
Tooling Knowledge	0.1582	0.0597	0.0667
Part Mfg Knowledge	0.0245	0.0250	0.0237
Process Improvement	0.1694	0.2230	0.2495

Table 3: Consistency Index

	Evaluators					
	1		2		3	
ATTRIBUTES	CI	CI/RI	CI	CI/RI	CI	CI/RI
Customer Orientation	0.0043	0.0032	0.0045	0.0034	0.0034	0.0026
Initiative	0.0132	0.0100	0.0060	0.0046	0.0281	0.0213
Verbal Skills	0.0478	0.0362	0.0157	0.0119	0.0134	0.0102
Quality Commitment	0.0097	0.0074	0.0668	0.0506	0.0051	0.0038
Problem Solving	0.0101	0.0076	0.0045	0.0034	0.0079	0.0060
Assembly Knowledge	0.0094	0.0071	0.0243	0.0184	0.0142	0.0108
Composite Knowledge	0.0059	0.0045	0.0413	0.0313	0.0094	0.0072
Adaptability	0.0660	0.0500	0.0025	0.0019	0.0719	0.0545
SPC	0.0345	0.0261	0.0201	0.0152	0.0023	0.0017
Tooling Knowledge	0.0244	0.0185	0.0338	0.0256	0.0000	0.0000
Part Mfg Knowledge	0.0480	0.0364	0.0463	0.0351	0.0478	0.0362
Process Improvement	0.0118	0.0089	0.0203	0.0154	0.0079	0.0060

The committee performed a check for consistency for each attribute weight priority matrix and the normalized candidate response matrix. The consistency indices computed for both the job attribute weight matrices (table 3) and the candidate response matrices indicates there is sufficient consistency ($CI/RI < 0.10$) to use the pair-wise comparison results.

The committee created computed the final aggregate candidate scores by each interviewer (table 4). As shown, candidate A received the highest aggregate scores from all evaluators. The committee upon reflection, prior to reviewing these results, felt that candidate A was the best choice. This decision was based on this person's thorough knowledge in the technical area of interest, good verbal skills, and experience with foreign assignments.

The committee reviewed the numerical difference in the results between each candidate. It was noticed that though candidate A was ranked highest, only evaluator 1 rated this candidate significantly greater (approximately 43%) than the next highest candidate. An argument can be made for candidate C as evaluator 2's rating of candidates A and C are separated by only 1.9%. Also, candidate A's rating from evaluator 3 rated approximately 4.4% greater than candidate B. Currently, AHP does not have a means by which the evaluator can determine significance levels from the results. The committee recognized this limitation of AHP and instituted a qualitative review of the quantitative rankings. The committee's computation and review of the numerical rankings is considered as only a single phase of the total interview process.

Table 4: Aggregate Candidate Scores

	INTERVIEWERS			Geometric
	1	2	3	Averaging
A	0.2734	0.1939	0.2180	0.2261
B	0.1349	0.1631	0.2085	0.1662
C	0.1352	0.1903	0.0993	0.1367
D	0.1554	0.1664	0.1713	0.1642
E	0.0915	0.1580	0.1176	0.1194
F	0.1258	0.0590	0.0835	0.0911
G	0.0837	0.0693	0.0835	0.0785

The qualitative review by the committee seeks to place the ranking in perspective by understanding why each candidate was ranked accordingly. The committee agreed candidate A and B were scored high based on being the most technically qualified. The committee consensus was candidates C and D scored high because they possessed strong communicative skills. Though, the experiences of candidates C and D are not in the technical area of interest, their communication skills in presenting their past experiences resulted in ratings ranging from acceptable to excellent. Candidates E and F were ranked lower as a result of low scores in communication skills, initiative and customer orientation. The committee did feel they possessed more experience in the manufacturing area of interest. Candidate G was an example of a person possessing a good deal of experience in the technical area of interest but clearly lacking in communication skills. Each committee member felt that this person would not be effective in this position.

The geometric averaging of the evaluator's scores gave rankings that closely approximated the evaluator's individual rankings (table 4). Candidates A and D were ranked as one of the top 3 candidates in all evaluators and geometric averaging rankings. Candidates B and C were each included in two evaluators top rankings. Though the numerical values differed, the final candidate ranking of candidates (table 5) indicates that it did not matter whether a geometric averaging or an individual ranking was used. The committee's final choice was candidate A.

Table 5: Candidate Ranking

	EVALUATOR			Geometric
	1	2	3	Averaging
1st	A	A	A	A
2nd	D	C	B	B
3rd	C	D	D	D

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CONCLUSION

This study has demonstrated the use of AHP to eliminate some of the subjectivity and consequences of using a purely qualitative method in selecting personnel. This case study exhibited the effectiveness of using both quantitative and qualitative methods in arriving at a decision. The quantitative approach using AHP gave structure to the process, which can be used to defend the decision. The qualitative approach, which the committee used, explored the validity of the AHP results.

The AHP approach is not without its problems but, as shown, if fully considered during the model development phase the impact can be minimized. A properly developed job analysis can reduce the time required for members to arrive at an agreement by identifying the attributes of the preferred candidate. This committee found the development of a priority matrix template and a Consistency Index using a common spreadsheet minimizes the complexity of pair-wise comparison in computing the attribute weights and normalized candidate responses.

This study explored the use of geometric averaging and individual evaluator to establish the final candidate rankings. Each approach has advantages but this study's results indicate the preference depends upon the committee and the time allotted to make the decision. The geometric averaging approach applied at the final candidate ranking allows each member to express their own opinion on attribute importance and candidate response, while creating a single quantitative summary of those potentially diverse opinions.

Those who try to implement this process will find resistance from those who say the AHP method is too complex. My response would emphasize the critical nature of employee selection on the success of the manager and to the organization. So does this critical decision not warrant a thorough methodology? The use of a qualitative approach versus a quantitative approach is and will continue to be a subject of intense debate.

A further study of the AHP approach should be to evaluate the effectiveness of the AHP selection process by reviewing the selected candidate's job performance.

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